CHAPTER 5: Operation Part 6

ASHES AND SPARKS DRAG

The entrainment of ash and embers (burning wood fragments or "coals") can occur under certain conditions, especially when there is induced draft (and the possibility is increased by having "forced" air under the grate), when steam production is increased, or when the boiler is operating at a high combustion rate.

When the boiler load (degree of combustion) is high, generally, in either system (direct combustion or gasifier), entrainment of material (ash and burning wood fragments, embers) occurs due to the high air velocity between the grates and the rollers that form the combustion bed.

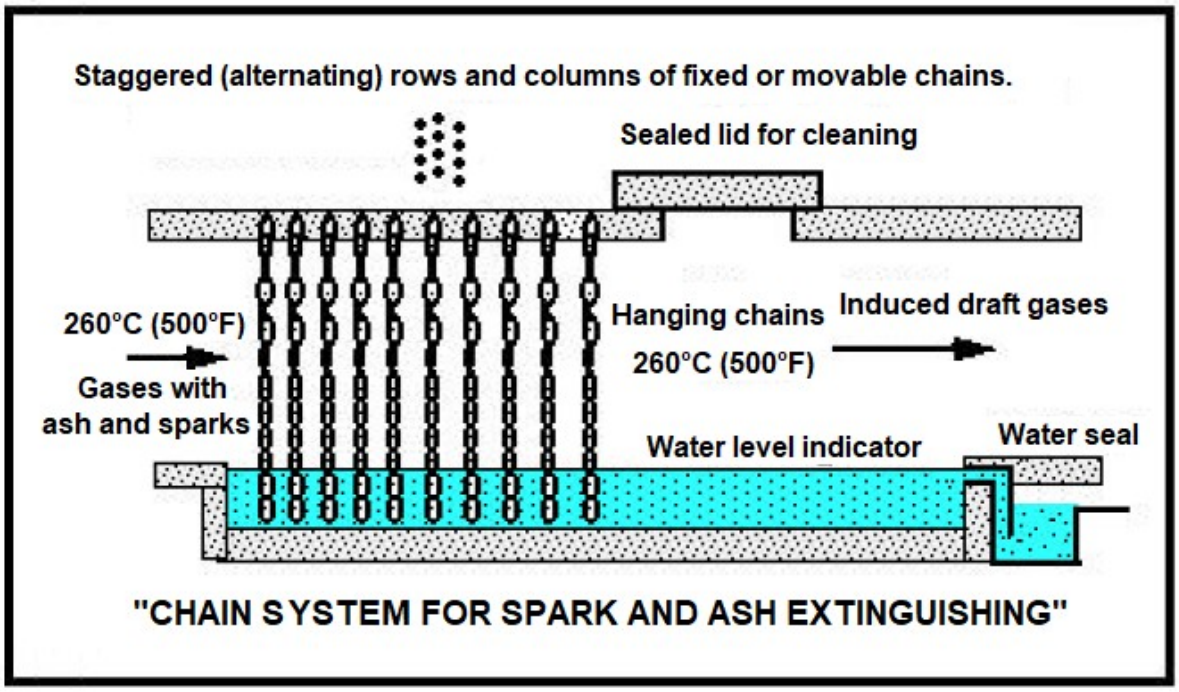
This is more serious the more ash the firewood contains (which increases with husks), and in the case of husks (like rice husks, where the ash content is over 20%), the more ash is carried away.

Ash is an environmental pollutant (especially when it is silica, like rice husks used as fuel), **but burning embers can be a fire hazard near boilers (especially in factories with flammable materials nearby).**

To prevent the carrying of ash and embers, the stoker's operation of the boiler and the quality of the firewood are fundamental, but this is generally not enough in some cases, **so it is necessary to install elements that "trap" the ash and embers (in this last case they call it a "spark arrester", but we will not make a difference).**

The most basic thing is to make a chimney base and a "low speed" chimney; the second would be to put in front of the induced draft a "tunnel" with a lower pool with a certain level of water (which has to be cleaned every so often) and with chains "hanging" from the top, almost touching one chain with the other and placed in a "staggered" pattern (that is, alternated, which force the gases to collide with the chains).

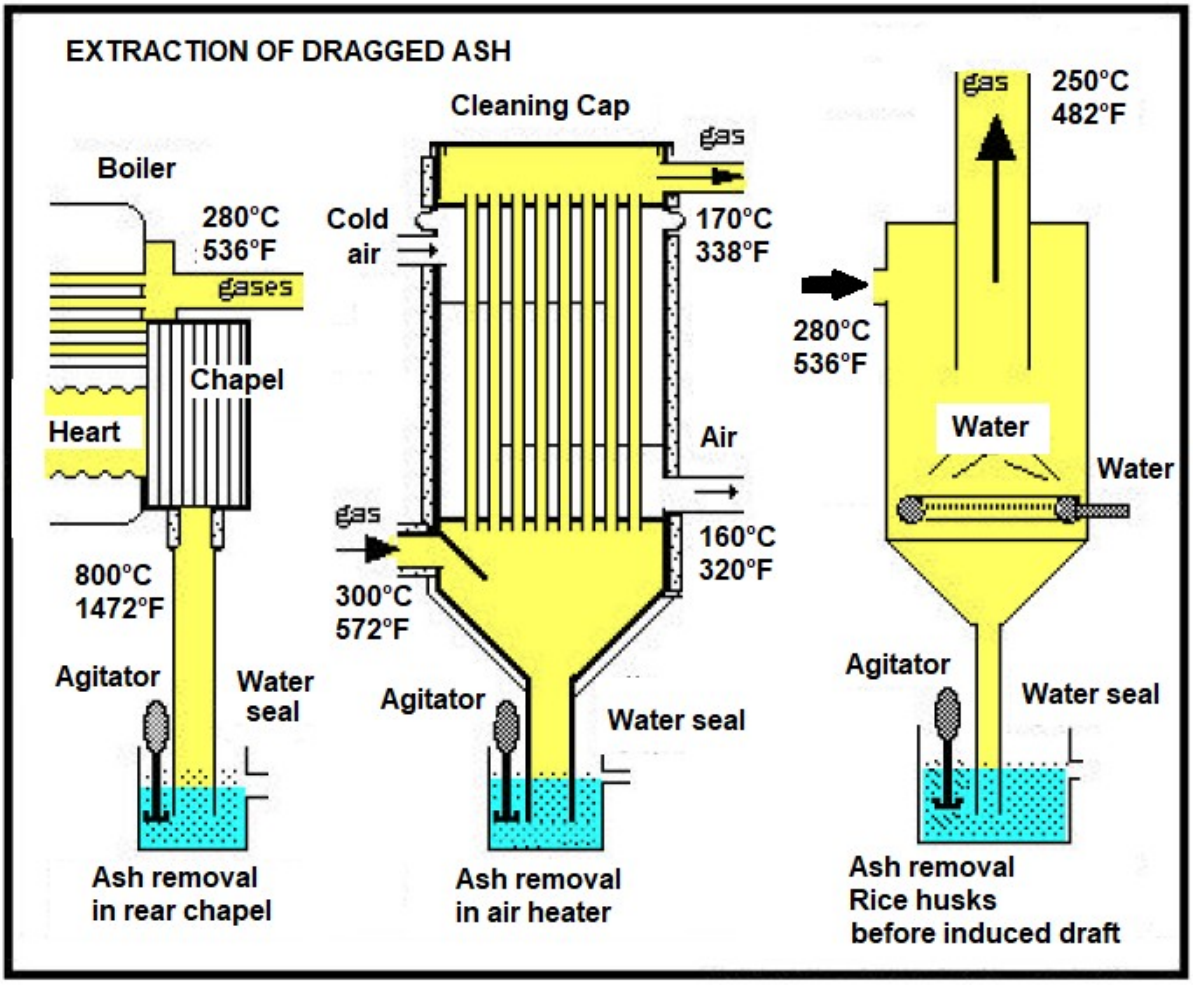
The dragged materials hit against the links, the chains being placed in several rows and columns (alternating in a “staggered” pattern); if the chain system has the possibility of a manual movement every now and then, all the better, to “detach” the material stuck to the chains).



To all this, the next step is to place between the induced draft and the last recuperator: a multicyclone (small cyclones in parallel, high speed, made of abrasion-resistant material, which discharge the ash into a common sealed chamber; the problem with this system is the high cost).

In the case of rice husks, I designed a "low-speed" system with a central bottom section using a water spray to trap the particles (this has worked very well, but it must be carefully designed, and the "abrasion" zone must be made of a "hard" and replaceable material; the water only "wets" the lower zone, where the particle density is highest, with the material separated by the water "falling" into a "water seal" with the cleaning basin running).

The gases should not be cooled with water, as this would prevent them from rising when they exit the chimney due to insufficient temperature. They need to rise to disperse into the atmosphere and not remain above the discharge area, since these gases have a very low oxygen (O2) content, a high carbon dioxide (CO2) content, and may contain carbon monoxide (CO) – toxic – and other unburned gases that are harmful to health. This concept should be considered with any fuel.



In addition, separators can be installed within the smoke boxes themselves (taking advantage of the reduced gas velocity and change in direction, by placing a discharge duct with a water seal and a cleanable basin at the bottom).

Care must be taken because the first part of the duct is in contact with gases at over 800°C, so the first part of the duct must be refractory and insulated. Ideally, the part in contact with the water should be made of stainless steel, or the entire duct if long-lasting durability is desired.

One of the problems with all separators is sealing the material collection "box" (ashes and incandescent matter). I prefer that these seals be made with "water seals" because they are more effective and also extinguish any sparks that fall (although they are usually of the "dry" type, which, because their lids do not close properly, causes air leaks that reintroduce the separated material into the induced draft system).

In general, **it is necessary to prevent the induced draft fan from being impacted by ash (there is abrasion, the case of rice husks is very severe), so it is advisable that the fan rotor and some areas of the fan housing be protected by harder material** (whether by layers of chrome-nickel welding in the most damaged areas, or by making "beads" that separate the "vein" of gases from the impact on the surfaces).

In the case of husks, when the ashes have a high silica content (as in the case of rice), preventing them from escaping through the chimney is very important, since this silica, when inhaled, can cause lung diseases (such as silicosis or others).

DIRECT-BURN ROLL LOADING SYSTEMS

One of the concerns to consider with direct-fired boilers is the method of loading the logs. Logs up to 1,200 mm (4 feet) long and up to 250 mm (10") in diameter are acceptable.

During boiler operation, if the boiler operator is exposed to the combustion chamber, they are at risk of a furnace explosion, but more importantly, they are exposed to the "bursting" of a furnace wall tube or grate support tube (although if the grates are made of cast iron, the explosion and discharge of water and steam usually occurs in the ash pan).

Historically, locomotive or ship boiler operators, when coal-fired, were exposed to the risk of explosions from the tubes against the burning coal mass (expansion of steam from its own superheated water plus the added

heat from the incandescent mass itself). Clearly, in a small boiler, the loading door is a simple opening (like a hinged door, see previous photo).

Solving how to isolate the boiler operator from exposure to a furnace or pipe explosion is a complex but not impossible problem.

In the case of small, side-loading boilers, the boiler operator is not only exposed to an extremely high risk, but also, each time the rollers are loaded, air enters that does not participate in combustion. This causes losses due to the incoming cold air being heated, "stealing" heat along with the flue gases.

Furthermore, it affects the boiler's performance, as it causes a loss of negative pressure in the furnace, preventing primary combustion air from entering the combustion chamber and thus causing the boiler to lose pressure.

There is an additional increase in loss due to the effect that the induced draft increases if it is with "automatic depression" because it does not detect the "set-point" vacuum, thereby increasing the losses due to hot chimney gases since it brings in more cold air that does not provide oxygen to the combustión.

BOILER EXPOSED TO A FIRE EXPLOSION
THE OPEN TOP COVER EXPOSES THE BOILER
AND HAS NO RETAINING LATCH

What should not be done is to expose stokers to explosions in medium and large boilers, as these boilers magnify the potential for explosions due to the large volume of water they can release (especially since they generally operate at higher pressures).

In these medium and large boilers, the problem of how to prevent stokers from being exposed to a furnace or tube explosion with high steam expansion has already been solved; there are solutions and ways to protect stokers, but unfortunately, these are not always implemented.

The loading "gates" for safety (for top loading) have two loading stages: a pre-loading zone where the rolls are stacked with the upper gate closed (which opens towards the combustion chamber, so that in case of an explosion it tends to close),

then an intermediate chamber that is loaded with the rolls from the "pre-loading" stage, but which has a high-temperature steel gate that isolates it from the combustion chamber.

This loading gate only opens when the pre-loading gate is closed and also closes as a lock in case of an explosion in the combustion chamber.

The great advantage of this double safety damper is not only that it protects the stoker in case of a furnace explosion or a chimney pipe failure, but also that it prevents air from entering through the dampers, so there are no losses due to the entry of "parasitic" air and the furnace negative pressure is not lost (which maintains the induced draft with the regulation of the "set-point" - the set point of the furnace negative pressure - which does not distort the operation of the boiler or produce losses).

Let's look at some diagrams of a "safe loader."

There is a pre-charge that the operator prepares. While the charge that has moved from the pre-charge to the loading area is sealed, no air has entered because the bottom cover is closed.

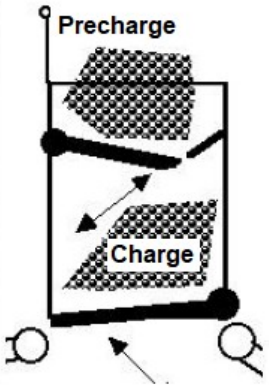
While the charge is being discharged into the combustion chamber, the pre-charge cover remains closed, preventing the stoker from being exposed to a combustion chamber explosion, while the operator prepares the pre-charge.

Once the charge is discharged into the combustion chamber, the charge cover is closed. Once closed, the pre-charge cover can be opened, again preventing the operator from being exposed and allowing air to enter the combustion chamber.

This system has four fundamental elements: the operator is not exposed to combustion explosions; no extraneous air enters (air that does not contribute to combustion and "steals" heat, escaping through the chimney as useless "excess air"); it does not destabilize the induced draft since the combustion chamber's negative pressure remains unchanged; and it allows for continuous loading of the logs into the firebox.

By simply observing the figure below, the reader will understand how the system works.

OPEN



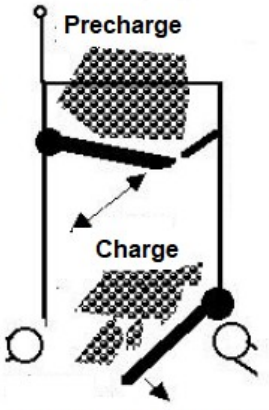
PRECHARGE

Precharging is done as soon as the upper door is closed.

When this occurs, the lower door opens.

CLOSE

OPEN



CHARGE

Charging is done with the upper door closed (it protects against stray air). Charging is almost continuous.

However, we must acknowledge that many boilers that, due to economic constraints, have not been fitted with safe "discharge dampers" or "chargers" often have unsafe chargers with a double cover.

But these do not provide operator protection, since the upper damper opens in the event of an explosion due to the pressure of the gases and steam against the damper, which opens upwards, not downwards as in a "safe" damper.

What is often overlooked is that a "safe charger," by preventing the entry of extra air and maintaining negative pressure, produces energy savings. The cost of the "safe charger" is recouped in months through fuel savings.

As seen in the photo above, a pipe "under the grate" (the grate support in a direct-fired boiler) is clogged or practically clogged with sludge.

This occurs in almost every boiler if the sludge isn't hosed out once a year.

Sludge in the boiler indicates that the water treatment system has failed in the water softeners, allowing hard water to enter. It also suggests possible contamination of the condensate returns with hard water.

Proper water treatment transforms hard water into sludge, which should be removed through the boiler's blowdown valves.

The sludge enters and circulates through the flue pipes, which is natural, since the flue pipes are connected to the lower part of the boiler, the area where the sludge settles.

Because the grate tubes have a slight incline, the sludge, following the flow of the circulation, cannot reach the upper collector that supports the grate at the top, and instead settles until it clogs the tube.

It does not exit through the blowdown valves, since the blowdown valves are located in the collectors, in the manifold tubes at the end.

The sludge enters before these valves and settles, clogging or nearly clogging them, thus preventing circulation.

A pipe with poor or no circulation is almost certainly prone to a "burst" due to overheating of the metal and the force of the water and steam pressure in the boiler. The loss itself, plus the expansion of the water against the combustion chamber, exacerbates the force of the explosion.

This demonstrates the danger posed by an "unsafe" charge system that exposes the stoker to direct contact with the combustion chamber during charging.